SPACE STATION PROGRAM RESPONSE TO THE FISCAL YEAR 1988 AND 1989 REVISED BUDGETS

Submitted to the
Committee on Appropriations
U. S. House of Representatives

and the

Committee on Appropriations
U. S. Senate

National Aeronautics and Space Administration

April 1988

NASA

National Aeronautics and
Space Administration

Washington, D C
20546

Office of the Administrator

April 12, 1988

Honorable Edward P. Boland
Chairman
Subcommittee on HUD-Independent
Agencies
Committee on Appropriations
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

With this letter I am transmitting a report entitled "Space Station Program Response to the Fiscal Year 1988-1989 Revised Budgets." This report responds to the requirement in the December 28, 1987, Joint Conference Report on Appropriations for the HUD-Independent Agencies that NASA provide its plan for rescoping and rescheduling Space Station activities to accommodate reductions in the FY 1988 and 1989 funding levels. This report also incorporates NASA's findings regarding the provision of an early man-tended capability on the Station.

The report provides NASA's assessment of the FY 1988 and 1989 budget situation. The agency has reviewed various means of accommodating the funding reductions--further descoping of the Station, changes to the program management approach, and slipping major program milestones. With respect to the first possibility, I believe that the current Station configuration is the correct one, and that descoping the design would be extremely unwise. The current configuration results from 4 years and over $600 million worth of definition analysis by government and industry. It has been reviewed by NASA and by the National Research Council. It represents, in my view, the optimal balance between development costs, operations costs and satisfaction of user requirements in a safe Station.

With respect to NASA's approach to program management for the Station, I believe that we have a sound, established and well-understood structure in place. The system represents the results of careful analysis several years ago, and it is now producing solid results. The balance between the efforts of the Work Package contractors and the other supporting contractual efforts leans towards the latter at this stage in the program before design and development activities have

gotten thoroughly underway. Currently, an early emphasis on supporting activities is establishing a firm foundation for the program. Beginning in FY 1989, however, the balance of program expeditures will begin to tip towards the Work Package contracts and, by the end of the development program, the monies spent on the hardware contracts will total a cumulative 65 percent of development funds.

It is my conclusion that the only sensible way to accommodate the Space Station funding profile inherent in the FY 1988 and 1989 budget reductions is to slip the major program milestones. The funding profile provided by the FY 1988 appropriation and the President's FY 1989 budget submission will necessitate a 1-year slip in the First Element Launch milestone to the first quarter of 1995. In making the scheduled adjustments necessary to accommodate the budget reductions, we have, however, been able to hold the launch date for the Station's polar platform to the fourth quarter of CY 1995. It is important to note that any further reductions to the funding profile would result in further delays in the major program milestones.

I regret that NASA cannot provide the Nation's scientific, technical and commercial users a permanently manned Space Station as early as we had originally planned. But the realities of the Federal budget environment are clear. Now, more than ever, it is important that we maximize user capabilities on the Station at the earliest possible point in the Station assembly sequence. To this end, we have changed the baseline assembly sequence for the Station in order to provide an early man-tended capability. Under the new baseline assembly sequence, the launch of the pressurized laboratory will be moved up to the fourth Shuttle assembly flight, which will occur in the fourth quarter of CY 1995.

Our studies indicate that such an early man-tended capability can be provided with minimal cost impacts, because this approach basically involves a reordering of the assembly sequence leading towards this nation's goal in the mid-1990's--a permanent manned presence in space. These cost impacts can be accommodated within the overall funding requested in the President's budget. This approach to providing an early man-tended capability would not delay the provision of permanently manned capability (PMC) on the Station. At the same time, it is important to note that delaying PMC would not aid in the provision of an early man-tended capability. Because of the commonality in laboratory and habitation module hardware and systems, very little front-end cost benefit would be realized from deliberately delaying PMC. In fact, delaying the habitation module would have negative impacts on the runout costs of the program.

Furthermore, lest there be any concern, because of the need to provide a crew safe-haven in the event of an accident in one of the modules, we cannot and will not permanently man the Space Station until the U.S. laboratory, resource nodes and habitation module are all available on orbit. Given this fact and our intent to use the Space Station during the assembly phase for research, the laboratory module will precede the habitation module in all assembly sequences.

Before the laboratory can be accommodated at the Station, a certain minimal amount of infrastructure is required. Specifically, Station truss structure and basic power, propulsion, guidance and control, and Shuttle docking systems must precede the arrival of the laboratory. The first three Shuttle assembly flights will put the infrastructure in place, and the fourth flight will provide the laboratory. With the current Shuttle, the laboratory will be launched with useful capability, and it will be fully outfitted on the sixth flight. With a Shuttle equippped with the Advanced Solid Rocket Motors (ASRM's), however, user outfitting could be as much as quadrupled on the initial launch of the laboratory. The ASRM program has a performance goal of a 12,000-pound payload increase on each Shuttle flight. Therefore, with ASRM's, an additional 12,000 pounds of user equipment could be made available on the fourth flight.

It is necessary to note that, although the acceleration of early man-tended capability will provide early access to users of Station pressurized volume, the new assembly sequence will slightly delay the launch of Station-attached science payloads. Under the previous assembly sequence, a number of attached payloads would have been placed on orbit on the third and fourth Shuttle flights. Under the new assembly sequence, the bulk of these attached payloads will have to be delayed until the sixth and seventh flights. Again, however, this situation could be ameliorated with ASRM's. The enhanced lift capability of the Shuttle with ASRM's would allow, volume permitting, the restoration of attached payloads earlier in the assembly sequence.

Astronaut crews on the fourth and subsequent flights will be prepared to conduct both assembly and utilization activities. It would be our intention--if the assembly sequence so permits and if utilization requirements so warrant--to insert an additional early Shuttle flight to provide dedicated crew to perform utilization activities. While an Extended Duration Orbiter (EDO) may not be useful in connection with Station assembly chores, an EDO could provide great advantages in this context--permitting enhanced manned interaction with early Station payloads.

I believe the enclosed report fully discusses the issues raised as a result of the changes in the Space Station Program's funding profile. If you have additional questions regarding NASA's actions to accommodate the FY 1988 and 1989 budget reductions or regarding NASA's plan to provide an early man-tended capability on the Station, we would be pleased to provide you additional information.

In closing, I would like to express my appreciation for your continuing support for the Space Station Program. This program represents a critical element in the Nation's efforts to reinvigorate leadership in manned civil space endeavors. The realization of the full scientific, technological and commercial potential of space requires the attention of men and women living and working on orbit. Man-tended activities, such as made possible by early man-tended capability on the Station, can be valuable steps along the path towards our ultimate goal--the permanently manned Space Station.

Sincerely,

James C. Fletcher
Administrator

Enclosure

cc: Honorable S. William Green

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Space Administration

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Office of the Administrator

April 12, 1988

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Sincerely,

James C. Fletcher
Administrator

Enclosure

cc: Honorable Edwin (Jake) Garn

SPACE STATION RESPONSE TO THE FISCAL YEAR 1988 - 1989 REVISED BUDGETS

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PREFACE

This report is submitted pursuant to the requirement in the Joint Conference Report on Appropriations for the HUD-Independent Agencies, dated December 28, 1987. The report language was as follows:

> ...The conferees direct NASA to provide the Committees on Appropriations a detailed plan rescoping and rescheduling the Space Station activities consistent with 1988 and 1989 revised budgets. In that connection, the conferees expect NASA to identify cost savings -- with special emphasis on the non-prime and program support areas....The revised plan for Space Station should be submitted to the Committees on Appropriations no later than February 29, 1988.

With the agreement of the Committees on Appropriations, it was agreed to defer until early April the provision of this mandated report and to incorporate into this report NASA's findings on the potential for accelerating the date at which a man-tended Space Station capability could become available.

EXECUTIVE SUMMARY AND CONCLUSIONS

The Space Station is a cornerstone of United States civil space policy. It is a tangible demonstration of this nation's commitment to space leadership. As a permanently manned research facility in space, the Station will permit scientific, technological and commercial advancement in space. And it will provide a foundation for the future extension of man's presence beyond Earth orbit into the solar system.

Historically, dollars spent by the U.S. Government in the aerospace industry have benefited the economy with a multiplier effect of about seven; thus, each dollar spent on the Space Station can be expected to result in a many-fold impact on the GNP. This effect translates into a more prosperous U.S. economy and jobs for Americans. It also results in the development of US technology for commercial gain, for sales abroad and for the benefit of mankind by contributing to our quality of life. Without the Station, the United States would be foregoing vast future opportunities for scientific, political and economic gain. Most importantly, the United States would be abdicating its role as the world leader in space activities.

In the President's FY 1988 budget request, NASA projected that on-orbit assembly of the Space Station would begin in the first quarter of CY 1994. This schedule was predicated upon funding for the Station at levels of $767 million in FY 1988 and $1.8 billion in FY 1989. In actuality, NASA received only $425 million for the program in FY 1988 and its FY 1989 budget request is only $967 million, representing a funding reduction of approximately 50% over those two years.

In its efforts to accommodate this substantially changed funding profile, NASA has reviewed those areas where changes might produce savings: the program configuration and content, the approach to program management, and the program schedule.

In its review, NASA has concluded:

- After many years and more than $600 million worth of program definition analysis by both government and industry, NASA has achieved a Space Station configuration that represents the optimal balance among development costs, operations costs, satisfaction of user requirements and safety. NASA believes that any further descoping of the Space Station would result in a serious negative impact on the capabilities required by Station users and/or an increase in operations costs resulting in increased overall life cycle costs for the Station.

- The management structure of the Space Station Program represents a balance between, on one hand, the application of NASA capability necessary to manage the program and, on the other hand, the development of a strong cadre of industry teams involved in the program. The industry teams will develop flight and ground hardware and software and they will also support NASA in its role as overall system engineer and integrator. Significant changes to this management structure at this late date would cause programmatic disruption. The Space Station will operate and evolve over several decades, and it is vital that NASA manage and control the development of the infrastructure.

- The reduction in FY 1988 and 1989 funding can only be accommodated by slipping the program schedule. Given the FY 1988 funding available and

assuming funding for FY 1989 at the level of the President's budget request, the program will suffer approximately a one-year slip in schedule. Thus, Station assembly on-orbit will not begin until the first quarter of CY 1995.

- Despite the one-year schedule slip necessitated by the reduced funding in FY 1988 and 1989, NASA intends to accelerate the availability of an early man-tended capability on orbit. Such a capability will permit earlier scientific, technological and commercial activity on the Station, thus reaping many of the benefits of the program at the earliest possible stage. NASA plans to provide the pressurized laboratory outfitted with useful capability on the fourth Shuttle assembly flight in the fourth quarter of CY 1995.

SPACE STATION PROGRAM RESPONSE TO THE FISCAL YEAR 1988 - 1989 REVISED BUDGETS

I. INTRODUCTION

The Space Station Program is now ready to move forward. The configuration has been baselined following a number of internal and external reviews to assess its responsiveness to user requirements, its development and operations costs, its safety and transportation requirements, the technology risk in the program, and the accommodation of the international partners. NASA has selected the appropriate configuration which properly balances development and operations costs while producing a Station which is safe and best meets user requirements. Now is the time to begin detailed development and design. To do that, the Space Station Program must begin to ramp up its funding to pay for the engineering and the equipment necessary to design and develop the Station flight hardware.

However, the funding available for FY 1988 and the President's budget request for FY 1989 represent amounts less than NASA had originally planned. NASA has reviewed program content, approach and schedule to determine how this reduction can best be accommodated. NASA believes that the revised baseline configuration cannot be changed in order to reduce development costs without introducing higher life cycle costs and/or penalizing needed research capabilities. Similarly, the management approach utilized in the program seems appropriate. Rather, NASA believes that the only sensible way to meet the imposed budget constraints is to re-phase FY 1988 and 1989 activities. Given the FY 1988 funding available and assuming funding for FY 1989 at the President's budget request level, it is NASA's assessment that the program will require approximately a one-year slip in schedule. It is important to note that the Space Station Program needs the full FY 1989 funding request if the design work is to be done at the pace necessary to maintain this new baseline schedule and keep the program slip approximately to one year.

Within the revised schedule, NASA will focus its FY 1988 activities on finalizing the baseline program requirements during the Program Requirements Review (PRR) process. PRR sets in place the specifications, operating parameters, cost guidelines, and performance criteria to enable the contractors to perform the detailed design of the Station. In addition, information system tools and structure will be put in place for program management as well as for flight and ground system software development and other management structure systems and processes will be firmly established; work will be conducted at the various centers involved in the program to continue testing of technology and preliminary engineering hardware and to complete development of test and integration facilities; and work will also be ongoing in defining utilization and operations design requirements. These activities and their products are as vital to the program as are the efforts under the Work Package contracts. They are needed to form the basis for detailed design in order to assure that the Space Station systems developed by the four Work Packages are compatible.

The Space Station represents a major investment in the nation's future in manned civil space endeavors. It is a vital part of the infrastructure that will help ensure American space leadership. Such leadership must be based upon solid achievements in space science, technology, and exploration. The Space Station will enable these accomplishments by providing a multipurpose facility in space -- a research and technology laboratory, an Earth and celestial observatory, and a point of departure

for the expansion of human presence and activity into the solar system. This important investment in space infrastructure requires vision and commitment today if we are to be successful as the leaders of tomorrow.

II. BACKGROUND

In early CY 1987, NASA presented its revised cost and schedule estimates for the then-baselined Dual Keel Space Station to the Administration. After review, the Administration sent forward to the Congress a plan for a Revised Baseline Configuration which not only descoped the Space Station, but also adhered to the budget estimates for FY 1987 through FY 1990 reflected in the President's FY 1988 Budget Proposal, submitted in January 1987. Whereas the previous NASA plan had envisioned a development cost of $14.5 billion (in 1984 dollars), a Work Package Contract Start Date of August 1987, and a First Element Launch (FEL) in January 1994, the revised baseline program and the FY 1989 and 1990 funding projections were based on a development cost of $12.2 billion (in 1984 dollars) and FEL in July 1994. In response to Congressional concern over the further delay in the FEL, NASA management agreed to commit to a March 1994 FEL. To provide assurance of meeting this March 1994 commitment date, the Space Station Program Office established an internal planning target of January 1994.

Due to the extensive debate within the Administration, and subsequently within the Congress, over the revised cost and configuration of the Space Station, the release of the Request for Proposals for the four Space Station Work Packages was delayed by several months to April 1987. As a further result of concerns about the amount of funding the Congress would appropriate for the Space Station in FY 1988, the Contract Start Date for the Work Package contractors was delayed from November 1987 to mid-December 1987. The result of the budget deliberations -- the Bipartisan Budget Agreement -- was a significant reduction in the Research and Development appropriation account for Space Station for FY 1988 -- from $767 million to $425 million of budget authority -- and limitations delaying the obligational availability of $225 million of the total until June 1, 1988. (As will be discussed later, the hiring and subcontracting activities of all Space Station contractors have been and will continue to be constrained in FY 1988, both by the delay in obligational availability and the limitation in total funding.) Complementary reductions were also made by the Congress in the Construction of Facilities appropriation account for Space Station facilities.

The formulation of the President's FY 1989 budget proposals for NASA and the Space Station reflected the Bipartisan Budget Agreement. Instead of the planned $1,845 million Research and Development amount for the Space Station for FY 1989, NASA agreed to revise its request to $1,000 million.* This revised amount was consistent with the slower-than-planned build-up of the program in FY 1988, and reflected the President's desire for fiscal restraint in avoiding a steep increase in FY 1989 spending levels. Coupled with this decision, the planned amount for facilities was reduced and a decision on Space Station staffing has been deferred until the completion of a NASA staffing study and a Space Station Management Plan.

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* The realignment among NASA appropriations mandated by the Congress subsequently led to the Research and Development amount being reduced to $392.3 million in FY 1988 and $967.4 million for FY 1989.

In order to provide greater stability to the program in the future, however, in his FY 1989 budget submission, the President proposed legislation requesting a Congressional commitment to a three-year advance authorization and appropriation of Space Station funds for FY 1989 through FY 1991. Later this year, the Administration also plans to request legislation to establish a total program cost ceiling. These measures on the part of Congress and the Administration will provide increased program stability while maintaining cost control discipline for both development and operations.

NASA is also developing revised program cost estimates, both annual and total, consistent with the current budget allocation. The revised estimates will include necessary adjustments to program milestones, including consideration of the utilization of the enhanced Shuttle performance made possible by approval of the Advanced Solid Rocket Motor (ASRM). This report and the evaluation of program costs and schedule contained herein provide NASA's initial assessment. The final assessment will be submitted following review of the revised program costs and milestones, consistent with the recommendations of the National Research Council's September 1987 report on the Space Station and the consideration of commercial proposals. NASA will undertake this review following the completion of PRR.

III. ASSESSMENT OF THE EFFECTS OF THE FY 1988 AND 1989 REVISED BUDGETS

Section VII of this report will present NASA's conclusion that the current Space Station configuration is the optimal one -- one that cannot be further descoped without jeopardizing the safety and usefulness of the Station and/or increasing overall life cycle costs. Section V of this report will describe the Space Station program management structure.

This section addresses the actions NASA has either implemented or is preliminarily baselining to accommodate the revised funding availability for FY 1988 and 1989. The combined effect of the FY 1988 and 1989 reductions has been to constrain the front-end program funding to approximately 50% of the level planned for these two years when the revised baseline program was submitted by the Administration a year ago. The amount of work that can be done in this period is obviously reduced and the assessed impact is approximately a one-year schedule slip in the First Element Launch (FEL) to the first quarter of CY 1995.

Funding Plan for FY 1988

As noted above, the original FY 1988 plan for the Space Station has been significantly reduced. The current funding plan in terms of budget authority in the Research and Development appropriation is $392.3 million. However, the planned level of activity for the Space Station for FY 1988 is based on an obligation plan of $513 million, including $121 million appropriated for FY 1987 but unobligated as of September 30, 1987. ($100 million of this $121 million was unavailable for obligation, due to conditions placed on its release by the Committees on Appropriations. As of the date of this report, the Committees on Appropriations have agreed to the release of all but $45 million of this $100 million.) Of the $392.3 million provided in NASA's current operating plan for funds appropriated to the Space Station for FY 1988, $225 million of this amount is unavailable for obligation until June 1, 1988.

Due to the limitations on funding available to the program through May 31, 1988, NASA has directed its four Work Package contractors (Boeing Aerospace,

McDonnell-Douglas Astronautics, General Electric, and Rocketdyne) -- now operating under letter contracts -- to constrain hiring of personnel and incurrence of costs for subcontracting efforts. This has allowed the contractors to retain key personnel but to add only the staff necessary to accomplish the tasks required to support the upcoming PRR. However, this constrained level led to the deferral of planned work required to be accomplished in advance of the PRR, with the result that the PRR will be completed in June 1988 instead of March 1988. The delay in completion of the PRR has consequently delayed initiation of the full scale detailed design activities. A gradual buildup of prime and supporting contracts and equipment procurements will take place after the June 1, 1988, release of FY 1988 funds.

Similar constraints have been placed on the hiring of manpower to support the program-wide engineering and integration analyses performed by the Program Support Contract (PSC) with Grumman Aerospace. Build-ups in the Technical and Management Information System (TMIS) and Software Support Environment (SSE) contracts with Boeing Computer Services and Lockheed Missiles and Space Company, respectively, have been deferred to fit the altered technical plans for FY 1988 (and FY 1989). In addition, the supporting development activities carried out at the NASA centers have been reduced. For example, critical test hardware and long-lead procurements have been deferred from six to twelve months. Procurements in FY 1988 of batteries and solar cells, for use in life testing and breadboard test hardware, were deferred until FY 1989. Also, delivery of engineering test hardware for the Environmental Control and Life Support System (ECLSS) was restructured to delete a parallel set of engineering test hardware.

Funding Plan for FY 1989

The impact of reducing program Research and Development appropriation funding in FY 1989 from $1,845 million to $1,000 million (now $967.4 million, after the transfer of $32.6 million to the Research and Program Management appropriation) was assessed by conducting a program funding requirements review. The NASA centers were requested to provide their estimates of funding requirements to meet a six-month slip in the Preliminary Design Review (PDR) (from January 1989 to July 1989), a nine-month slip in the first of the three planned Critical Design Reviews (CDR's) (from August 1990 to May 1991), and a twelve-month slip in FEL (from first quarter 1994 to first quarter 1995). In addition, the planned level of funding for early operations and utilization capability development activities was deleted (a reduction of $19 million). Furthermore, the provision for studies of evolutionary developments and advanced technology development was reduced from a planned $25 million to $14 million.

The responses from the NASA centers were based on their assessments of the adjustments necessary to phase the resource requirements provided in the Work Package contractor proposals -- which had been based on a first quarter 1994 FEL -- and to reschedule supporting development and operations and utilization capability development activities. The issues and concerns resulting from the Source Evaluation Board findings were also incorporated to the extent feasible prior to detailed negotiations with the Work Package contractors. At the Space Station Program Office, the manpower and procurements for PSC, TMIS, and SSE were assigned guidelines well below the level planned when the total program funding projection for FY 1989 was $1,845 million.

The NASA center responses indicated increased funding would be required -- amounting to approximately $500 million -- over the $967.4 million requested for FY 1989 to meet the guidelined milestones. A series of detailed reviews to clarify near-term program requirements resulted in deleting some defined activities not directly related to the program. However, the principal finding from the reviews was the realization that the program approach for a single program-level PDR required completion of engineering analysis and designs for all program elements, even those whose planned launch or operational readiness dates did not necessitate early completion. This approach had the effect of requiring major build-ups in engineering manpower and supporting development and testing, driving the front-end funding requirements. As a result, the Space Station Program Director decided that the PDR should mirror the approach selected for the CDR's: a phased approach, providing separate PDR's for different program elements with the schedule tied to the timing of hardware readiness dates for the launch assembly sequence. The milestones for the reviews were accordingly rephased to resolve the front-end funding problem.

All of these detailed program schedule adjustments, coupled with the scrubbing of some defined requirements, have resulted in a funding plan for FY 1989 and subsequent years which conforms to the NASA budget estimates contained in the FY 1989 budget request and the delay in FEL has been held to one year.

Effects on Program Runout Costs of FY 1988 and 1989 Reductions

NASA's past experience with major development programs indicates that schedule delays caused by front-end funding reductions invariably result in increased program costs. The potential for cost increases generally fall into four categories: (1) those due to the need to retain the technical/engineering teams and the underlying program support base for an extended period of time; (2) those due to inflation, in which dollars spent in the future simply have less purchasing power than dollars spent today, and (3) those due to program task accomplishment inefficiencies, caused by hiring freezes and lay-offs, issuance of stop-and-go work orders, and uneconomical activities like inefficient purchasing of manufactured parts and materials; (4) those due to increased program schedule/technical risk, caused by deferring scheduled activities until there are too many concurrent activities on the critical path. The impact of the funding reductions on the Space Station Program is related to the first two of these.

With regard to the first category, the retention of a fixed technical/engineering and support base for the Space Station for an additional year, the amount of fixed base is estimated for the period impacted. The detailed manpower plans for the program are still being definitized. However, NASA would expect the total costs to increase for the development program schedule.

With regard to the second of these categories, the impact is estimated by assuming a given inflation rate (in this instance, a compounded rate of 5.1% per year) over the preliminary outyear funding stream calculated in current dollars and then inflated. The inflationary impact on the development cost is under review but is expected to increase due to rephasing of funding requirements over the extended period.

The potential for increased development costs due to program task inefficiencies and increased program schedule/technical risk resulting from funding reductions will only be understood as the program progresses through the design and

development phase. At this early stage of the program, there is only a qualitative recognition that funding constraints will result in the potential for increased program costs in these areas. NASA has not assigned a quantitative value based on past program experience for these factors.

It should be noted that there is another, also qualitative, element which could lead to cost growth in the Space Station Program. If continued budget reductions occur in the Space Station in FY 1989 and future years, there is a real potential that both NASA and its contractors will experience difficulties in attracting and retaining the highest caliber of experienced and skilled men and women. A well-documented case of this kind of impact was experienced by NASA and General Dynamics on the Atlas-Centaur launch vehicle program in the early 1980's. Reductions in funding on this program led to the early retirement and reassignment of skilled engineers and technicians; after the downturn in vehicle procurements, the relatively junior engineers and technicians committed a number of errors which caused high manufacturing scrappage rates and increased numbers of manufacturing and engineering support hours per vehicle. Similarly, a perception of low program priority could impact the Space Station in hiring, retention, and morale of those who elected to stay on, with obvious negative effects in productivity and quality control.

In summary, the program cost and schedule are under review with revised program cost estimates and schedules to be provided later this year. These estimates and schedules will also reflect the use of the Advanced Solid Rocket Motor for Space Station assembly.

IV. AN EARLY MAN-TENDED CAPABILITY

At the request of the House Committee on Appropriations Sub-Committee on HUD-Independent Agencies, NASA has carried out a study to assess options for an early man-tended capability. Despite the schedule slip resulting from the FY 1988 and 1989 budget constraints, NASA has concluded that it is possible to make the Station available for pressurized payloads at an earlier date than would be envisioned in the new baseline schedule with its one-year slip of major program milestones. While it is not possible to move up the FEL date at these reduced levels, NASA will re-baseline the assembly sequence, making the laboratory outfitted with useful capability available by the fourth Shuttle assembly flight in the fourth quarter of CY 1995.

The study, conducted in February and March 1988, addressed numerous options for providing an early man-tended capability. Participants in the study included representatives from the Space Station Program Office's Systems Engineering and Integration Group and Utilization and Operations Group, the four Work Package contractors and centers, the international partners, and the Astronaut Office at Johnson Space Center. As a first step, the report on a man-tended Station, submitted to Congress in 1986, was revisited. The participants then established a set of guidelines and constraints, identified ten technically feasible options, and compared them in terms of cost, safety, user payload benefit and impact on the assembly sequence.

Criteria for the study included the following: 1) the options were to provide significant pressurized volume with significant man-tended materials science payload capability; 2) they were to permit an orderly assembly to Space Station completion; 3) they were not to add any substantial new hardware to the Revised

Baseline Configuration; 4) assembly was to be carried out with the current Shuttle; and 5) the options were to be capable of sustaining payload operations both during Shuttle visits and via automation and telescience during unmanned periods.

The most compelling reason for pursuing an early man-tended capability is to have research capabilities in place ready to be used on the Station at the earliest opportunity. The selected approach, under which NASA plans to launch the laboratory module on the fourth assembly flight, could provide meaningful laboratory research capabilities early in the program. However, it is necessary to note that bringing the laboratory up on this flight necessitates that the bulk of the major science and technology attached payloads previously planned for launch on the third and fourth assembly flights will have to be slipped to later flights.

The selected approach will provide launch the laboratory on the fourth assembly flight in the fourth quarter of CY 1995. At that point, the Station on orbit will comprise half the truss, two resource nodes, 18.75 kW of power from one power module, the propulsion system, the docking system, the guidance and control system, part of the fluid management system, and the TDRSS antenna for the communications and tracking system (see Figure 1).

The laboratory will be launched on Flight 4 outfitted with four double racks of user experiments; by Flight 6, the laboratory will be fully outfitted. It should be noted that a Shuttle-equipped with Advanced Solid Rocket Motors (ASRM's) would provide a significantly more fully outfitted laboratory on the fourth flight. Using the ASRM, with a performance goal of a 12,000 pound payload increase on each Shuttle flight, could quadruple the amount of experiment equipment initially available in the laboratory. Additionally, ASRM's would provide increased Shuttle capacity to launch attached payloads early in the assembly sequence. An ASRM-equipped Shuttle would not permit the laboratory to be launched earlier in the assembly sequence because a minimal amount of Station infrastructure must be available on-orbit in order to accommodate the laboratory. When the laboratory is delivered, 8 kW of power will be available for research; approximately 10 kW will have to be used for housekeeping. On the first or second subsequent flight, another solar array, supplying an additional 18.75 kW of power, and additional truss structure will be brought up, increasing power levels for Station obligation to 25 kW and improving the microgravity environment by balancing the mass on the Station.

NASA review indicates that in order to accommodate an early man-tended capability, some hardware in the program will have to be rephased. However, there are no significant cost increases impacting the overall program budget. Furthermore, it is not anticipated that the selected approach to early man-tended capability will result in any changes to any of the other program milestones, e.g., permanently manned capability.

V. REVIEW OF PROGRAM MANAGEMENT

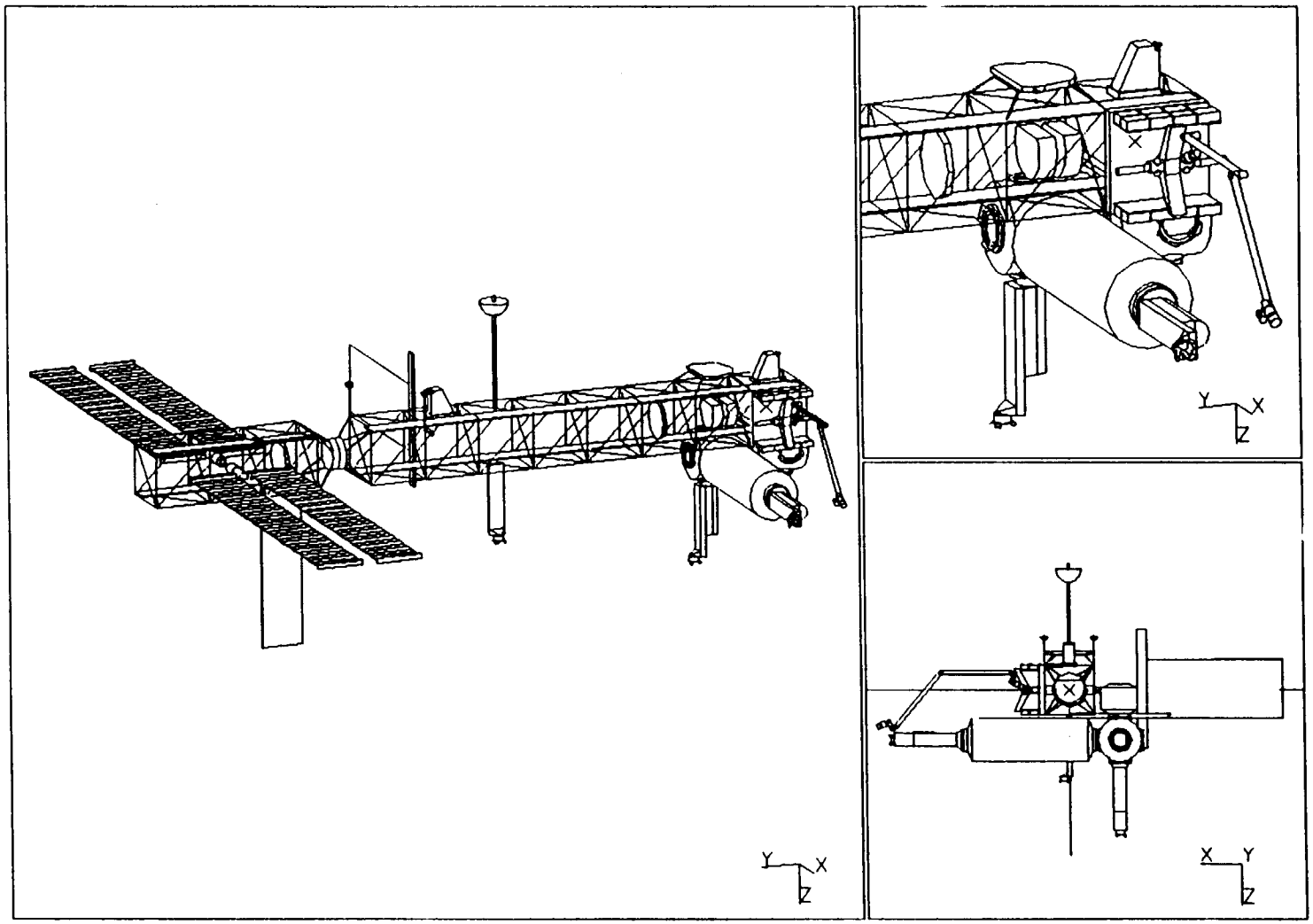
The management structure of the Space Station is firmly in place, and, under it, NASA Headquarters, the NASA centers, and all of the contractors are communicating and working effectively with one another.

The Space Station Program, like the Apollo and the Space Shuttle programs which preceded it, does not have a prime contractor in the classic sense. During the Apollo

Figure 1

EARLY MAN-TENDED CAPABILITY

LABORATORY ON 4th FLIGHT



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Program, NASA executed its prime role through the Apollo Program Office in Washington, DC. For the Space Shuttle Program, that role was delegated to the Space Shuttle Program Office at the Johnson Space Center. In the case of the Space Station Program, the role is assigned to the Space Station Program Office in Reston, VA. Partitioning of responsibilities in the Space Station Program was influenced very strongly by the findings of the Presidential (Rogers) Commission on the Space Shuttle Accident and by the subsequent recommendations of a committee tasked by the Administrator to review NASA management issues. This committee was headed by Retired Air Force General Samuel Phillips who directed the Apollo Program. A strong program office was established, which has retained responsibility for program-level system engineering and integration of all Space Station systems and elements. The major portion of the Space Station flight hardware has been divided into four Work Packages and assigned to the NASA Work Package centers.

It is important to realize that the four Work Package contracts do not by any means represent the entire contractual effort that is required to design, develop and integrate the Space Station. Beyond the Work Packages, other NASA contractors will participate in the areas of management and integration activities, in supporting development work, and in operations and utilization capability development. These three areas plus the Work Packages represent the four areas of contractual effort vital to the management structure and to the success of the program.

Management and Integration

The management structure of the Space Station features NASA in the role of overall system engineering and integration manager. This approach allows NASA to control the base of the technical knowledge needed in order to run the program over its extended lifetime. Providing major support to NASA in its role of system engineer and integrator are three key contracts: the Program Support Contract (PSC), the Technical and Management Information System (TMIS), and the Software Support Environment (SSE).

PSC: Early in the definition phase, NASA decided to retain the system engineering and integration responsibility in-house. As the magnitude of the effort became clearer and as the demands of the Shuttle recovery and other program requirements on NASA technical resources became better understood, the decision was made to seek the help of an industrial partner. NASA has retained the leadership role in the systems engineering and integration effort, but has obtained the support of Grumman Aerospace Corporation and its subcontractors to implement this vast responsibility. NASA's effort, with the support of PSC, is critical to the development of detailed program requirements, interfaces, standards and the control and integration of thousands of subsystems being developed by U.S. contractors and the international partners. NASA planning for the PSC, as announced to industry in the February 1987 Request for Proposal was to build up to a manpower force of 1000 by FY 1989. With the continued budget constraints, NASA has revised the planned staffing levels to less than 800 in that timeframe.

TMIS and SSE: TMIS and SSE are tools needed to integrate all of the pieces of the program. One of the major challenges associated with a program as large and complex as the Space Station is to find ways to effectively coordinate and integrate information and software among the many participating organizations. This situation is not unknown to NASA. Previous major programs such as Space Telescope and Space Shuttle have resulted in a vast experience base which has provided two major lessons. First, it is critical that programmatic information be

easily generated, kept current, and readily exchangeable. Second, an infrastructure should be in place to support the management and development of software. To be effective, this infrastructure must be in place before detailed design and development is underway. Otherwise the many contractors and international partners in the program will each produce their own software using different systems and environments, duplicating many costs, and causing considerable integration, maintenance and operational problems over the life of the program. Early in the Space Station program, NASA capitalized on its experience and conceptualized two systems -- TMIS and SSE -- that together provide this necessary infrastructure.

TMIS is an integrated system of automated data processing hardware and software, communications, procedures, databases and people. It provides services critical to Space Station program management - information integration, rapid and efficient program communications, and information for successful Space Station operations and maintenance. TMIS provides cost avoidance by: 1) eliminating duplication in producing much of the program's information; 2) maintaining the information base which will be vital for the sustaining engineering of the operational station; 3) providing standards that allow many of NASA's existing systems to use TMIS-stored information without costly conversions; and 4) increasing NASA staff productivity. With respect to this first point, such productivity gains have been documented in numerous studies, including those by the National Academy of Sciences, by many of the Space Station's major contractors, particularly Boeing, and by NASA itself.

SSE will provide the environment -- that is, the common hardware, tools, standards and procedures -- with which Space Station software will be developed. The development of a common environment will ensure that each of the major contractors, who will write the actual application software used on the Station, will develop compatible software. This common environment will greatly simplify, and thus reduce the cost of, integration and long-term maintenance of the Space Station flight and ground software.

Supporting Development

NASA's strength as an institution lies in its people and facilities. The supporting development activity contains NASA's plan for bringing its considerable institutional resources to bear on the Space Station Program and, thereby, for reducing overall program cost and risk.

Within the supporting development activity, NASA is undertaking technology development efforts for which it uniquely has the skills. Examples of such technology efforts are the utilization of existing NASA/contractor teams in areas like the development of a high pressure space suit and the Health Maintenance Facility. The NASA/contractor expertise in space suit development dates back to the Gemini program. Similarly, expertise related to the development of a Health Maintenance Facility is also resident within NASA. This facility will provide the routine and limited emergency health care available to astronauts on the Space Station. It will also be used to provide the countermeasures needed to combat the physiologically deteriorative effects of weightlessness. Other examples of unique NASA capability include the modeling of the particulate and electromagnetic environment of low-Earth orbit and the use of this capability in the evaluation of materials and design options.

Another example of the use of broad NASA capabilities in the Space Station Program is the program's use, wherever possible, of existing NASA facilities rather than the development of Space Station-unique facilities. Although it will be necessary to build new NASA facilities for the program, NASA's past development, test and operations of manned and unmanned space projects have produced a legacy of facilities at all the Work Package centers. Many of these facilities have been in use and maintained continuously. They are now available to support the Space Station Program. Other NASA facilities will require some restoration, modification and updating of capabilities. In total, however, the use of existing NASA facilities represents a substantial cost avoidance for the program. These savings will occur not only in the development phase of the program, but later during operations as well. By optimizing the utilization of government facilities, NASA can minimize contract expenditures and facilitate future re-competition throughout the operations phase of the program.

In every program, NASA has historically worked closely with the contractor in his subsystem designs. This has allowed NASA to stay involved in the design process; it has brought NASA's expertise to bear on problems as they arise, thus helping the contractor resolve them; and it has provided NASA the ability to keep equipment operating long after the contract requirements were met and the contractor's staff moved on to other jobs. Without this subsystem involvement, program risk would escalate and the cost of ownership after equipment delivery would become excessive. Work Package center involvement with the Space Station Work Package contracts will reap similar benefits.

Operations and Utilization Capability Development

To allow the Space Station to be a useful facility as early as possible, the Space Station Program has already initiated substantial activity for operations and utilization capability development (OUCD). The early funding for OUCD was deleted for FY 1989, but planning for the effort is still on-going. To capitalize on the vast body of knowledge the agency has developed in operating and using past manned and unmanned space assets, a Space Station Operations Task Force was formed in late CY 1986. The task force produced a report documenting its findings in October 1987. Using the task force's findings as a blueprint for implementation, the program has developed a plan which capitalizes on NASA's past experience, utilizes industrial partners in major roles, and takes advantage of synergistic relationships to other ongoing programs.

The operations and utilization capability development efforts include putting in place the necessary infrastructure to process Space Station elements and payloads for launch at Kennedy Space Center. It also includes the infrastructure needed to conduct the logistics at Kennedy through the operational timeframe of the Space Station. The Space Station Control Center and other infrastructure necessary to conduct Space Station operations from the Johnson Space Center are also a part of the OUCD effort. This latter infrastructure includes a distributed set of Engineering Support Centers located at the other Work Package centers, the Payload Operations and Integration Center at Marshall Space Flight Center, and the networking required to interface with discipline operations centers distributed throughout the country and the free world. Preparation for the training of the Space Station ground and flight crews is also included in OUCD. Centered at Johnson, this activity will share a number of resources with similar efforts in the Shuttle program.

Industry is participating in all facets of the OUCD effort. Contracts exist and others will be written to outfit and maintain the appropriate facilities, and most of the operational effort will be provided by contracted manpower. As in the case of system engineering and integration, NASA has retained the leadership role. This will allow the Agency to maintain a heaithy competitive environment in all procurements throughout the life of the Space Station.

Summary

In summary, all of these elements of contractual support in the program represent crucial aspects of the program. (These are the areas of contractual effort which are sometimes called "non-prime" to contrast them from the "prime" contractors leading the Work Package efforts.) By their very nature, the efforts in these areas have required a relatively large proportion of the early funding in the program. This has been necessary because these activities are laying the foundation for the program. Without them, the work packages would cost more; the program risk would be higher; NASA's unique expertise would not be utilized effectively; and integration, assembly and operations would be far more difficult. To date, at this early stage in the program before design and development activities have gotten thoroughly underway, the Work Package efforts have used only about one-third of the program funding, with the other activities laying down a firm basis for later Work Package activity. In FY 1989, however, the Work Package efforts will consume over half of the funding; by the end of the development program, NASA's initial assessment is that this will increase to approximately 65 percent of the program funding (See Figure 2). These additional activities have been and will continue to be subjected to the same scrutiny as the Work Package elements of the program. They have been critically reviewed to reduce their cost. Work has been deferred to accommodate changing budget levels, but, as with the Work Package contracts, any reduction in the scope of activities will have a serious impact on the effectiveness and efficiency of the program.

Figure 2

SPACE STATION DEVELOPMENT PROGRAM
FUNDING FOR VARIOUS ELEMENTS OF THE CONTRACTUAL EFFORT

	FY 88	FY 89	ESTIMATED AT COMPLETION
Work Package Contracts	39.4%	56.3%	65.4%
Management & Integration	32.8%	18.1%	12.2%
Supporting Development	22.1%	17.0%	12.9%
Ops/Utilization Capability	5.7%	8.6%	9.5%
TOTALS	100.0%	100.0%	100.0%

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VI. GENESIS OF REQUIREMENTS FOR THE SPACE STATION CONFIGURATION

In 1984, President Reagan called upon NASA to develop a "permanently manned Space Station" within a decade which would help ensure that the United States maintained its leadership in space. The President stated that the Space Station would "permit quantum leaps in our research in science, in communications and in metals and life-saving medicines which can be manufactured only in space." In addition, the President invited international participation in the Space Station, thus initiating a multinational project greater in scope than any previous cooperative effort in science and technology.

Shortly after the President's call to action, NASA organized major user workshops to determine and assess potential payload and experiment requirements for the permanently manned Space Station. The results of the workshops led to the development of the Mission Requirements Data Base containing hundreds of individual payloads and experiments, representing inputs from the United States, Europe, Japan, and Canada. Materials science and processing, life science, technology, observational, and environmental study requirements were included.

Studies were also conducted to determine those Station capabilities which would be required to support potential planetary as well as near-Earth missions. These requirements included large space structure assembly capabilities and the capability to support technology research and development related to applications of superconductivity, advanced energy, propulsion, communications, and radiation and micrometeoroid protection systems which would be needed for future space utilization initiatives.

Congress has also provided several guidelines to enhance the utility of the Space Station. These guidelines include the early provision of a fully outfitted laboratory module, a Station power level of 75 kW, a capability to support early attached payloads, and an emphasis on the use of automation and robotics to support Station and user operations. In addition, Congress has also directed the continuing development of technology for evolutionary capabilities for the Space Station, including payload/free-flyer servicing and solar dynamic power. From the beginning, an emphasis has been placed on commercial utilization of the Station. This policy thrust is consistent with the national space policy to encourage private sector investment and involvement in space and space-related activities. It is also responsive to early success in commercial microgravity research activities on the Shuttle. Capabilities necessary to accommodate rapid response research requirements and to address private industry's proprietary concerns have been identified and are being developed. Requirements for supporting commercial free-flying laboratories and permanently attached user-supplied mini-laboratories are also being addressed. Furthermore, NASA is developing plans and processes for greater private sector investment and involvement in the Space Station program, including financing, development and operations to the maximum extent feasible.

VII. EVALUATION OF SPACE STATION CONFIGURATION OPTIONS AND PROGRAM CONTENT

After extensive analysis, NASA has developed a design concept for the Space Station that effectively balances user requirements, technology development, operational considerations and program cost. This configuration has emerged after many years during which NASA and industry have invested more than $600 million in technical analyses related to program definition. To appreciate that the configuration

represents the optimal accommodation of all important factors, it is important to understand the process that NASA has undertaken in reaching the Space Station Revised Baseline Configuration.

NASA has undertaken continual study and review of the Station configuration and program content since 1982. Early efforts laid the groundwork for the President's decision to proceed with the program. Mission analysis studies and configuration options were provided by NASA contractors in 1982. NASA organized a Space Station Task Force which developed a reference configuration in 1983. After the announcement of the President's decision in January 1984, the program entered into a more formal and detailed study and review process of Station configuration and program content. As discussed in the previous section, a major criterion in assessing Station configuration and program content issues has been the requirements provided by the President, the Congress, and the user community. Other major requirements which bound the configuration and content are safety, Shuttle transportation, development costs, annual budget availability, operations management and costs, technology capability, and evolutionary capability.

The program has continued to study various configuration and content options. The process has, at every stage, involved the balancing of all the various criteria in order to provide an optimal Station. It is possible to design a Station which costs less to develop, but it will fail to meet other important criteria. In all cases, the cost to operate such a Station is greater or the lost benefits are major. The Space Station configuration and content as currently defined in the Revised Baseline Configuration represents the best Space Station that can be developed for the proposed funding profile and still satisfy all of the basic requirements in the most balanced manner. The following pages provide a discussion of the various configuration studies, management studies, cost studies, and program reviews that have been conducted from 1984 through the present. Each of these activities has contributed to the development of the current Revised Baseline Configuration. Figure 3 lists the various studies and the periods during which they were conducted.

The Power Tower

In April 1984, the Space Station Program Office was established at the Johnson Space Center. The Program Office immediately instituted a configuration review to define the Space Station configuration that would be provided to industry in Requests For Proposal for the definition phase effort. This configuration was also to serve as the initial baseline from which industry would conduct definition trade studies. The Power Tower configuration was selected.

The Power Tower was a single vertical keel flying in a gravity-gradient mode with articulated solar arrays at the upper end, and five modules mounted at the lower end. Of the early configurations considered, it was concluded that the Power Tower best met the basic requirements of the program: 1) it provided 75 kilowatts of power at the time of initial operating capability; 2) it incorporated large structures and platform servicing; 3) it allowed simultaneous and continuous Earth, celestial and solar viewing; and 4) it could be scarred for future evolution. Also, the distribution of its mass made it inherently flight stable.

Figure 3

SPACE STATION CONFIGURATION EVALUATIONS

STUDY/REVIEW	DATE
Power Tower	Spring 1984
Systems Requirements Review (SRR) Configuration Study	Spring 1986
Dual Keel	Spring 1986
Man-Tended Study	Spring 1986
Critical Evaluation Task Force (CETF)	Fall 1986
Operations Task Force	Fall 1986
Cost Commitment Review	Winter 1986-87
Configuration Options Study	Winter 1986-87
National Research Council (NRC) Review	Summer 1987
Science Operations Management Concepts Study	Summer 1987
Transportation Study	Summer 1987
Systems Operations Study	Winter 1987/88
Early Man-Tended Options Study	Spring 1988

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The Dual Keel

The program selected eight contractors in April 1985 for detailed definition and preliminary design. Various design trades were conducted on the overall configuration as well as on the different systems (power, data management, environmental control and life support systems, etc.). These trades not only considered technical and user criteria but also involved the evaluation of both development and operations costs. For example, a closed loop ECLSS was selected that cost more in development but provided significant savings in operations cost. In March 1986, at the Systems Requirements Review, the program modified the Station configuration to the Dual Keel, primarily to satisfy user requirements more effectively. The Dual Keel moved the modules to the center of gravity along the transverse boom and also increased the amount of truss structure. These changes increased the scientific usefulness of the Station by improving the microgravity environment, increasing Station capacity to accommodate attached payloads and providing a more advantageous location for the servicing bay.

During this same timeframe, the program evaluated the anticipated international contributions to the program. The program content was modified to accommodate these contributions. In particular, the number of United States laboratories was reduced from two to one, based on the increased size of the modules and on the United States having space available in the European and Japanese modules.

Systems Requirements Studies Following the Baselining of the Dual Keel

Having established the baseline Space Station configuration, the Space Station program undertook to conduct a "scrub" of the systems and their requirements in order to reduce program costs. This effort involved all of the Work Package centers and their contractors. In that review, it was determined that only a single habitation module would be needed to accommodate a crew of eight. Furthermore, plans for a Station-based Orbital Maneuvering Vehicle were deferred, and Station systems and subsystems were reviewed meticulously to assure that only those capabilities directly related to program requirements were retained.

Man-Tended Study

In response to a request in NASA's 1985 Appropriations Act, NASA produced a report on a man-tended configuration in May 1986. This configuration was not intended to be a replacement for the Dual Keel Space Station; rather, it was intended to define that point in the Space Station assembly sequence at which the Space Station could be used to conduct productive research prior to its being permanently manned. The study recognized the value of providing early user capability through the provision of a man-tended capability. At the same time, the study also demonstrated that the user support capabilities offered by the man-tended capability were significantly less than those provided by the permanently manned configuration.

Critical Evaluation Task Force

As part of the aftermath of Challenger accident, NASA established the Critical Evaluation Task Force (CETF) at Langley Research Center in September 1986 to reassess the validity and safety of the configuration. The CETF review was conducted with support from each of the other centers, the Space Station contractors and the international partners. This review, which focused mainly on

technical configuration and crew safety issues, was prompted by Congressional concerns over Space Station management changes and by concerns of the JSC Astronaut Office about the amount of extravehicular activity needed to assemble the Dual Keel configuration. Another major concern addressed by the CETF review was the matching of the Space Station assembly sequence with the revised transportation system capability. These revisions had been driven by modifications to the Shuttle in order to enhance safety following the Challenger accident. A major outcome of the CETF review was its revalidation of the Dual Keel configuration. In addition, recommendations were developed by the CETF to meet the technical concerns about safety, EVA time, assembly sequence, early productivity on the Station, operations and transportation.

The Revised Baseline Configuration

In September 1986, NASA initiated a major cost review of the Space Station Program at the direction of the NASA Administrator. The purpose of the review, conducted by all elements of the program, was to provide a thorough and detailed assessment of cost estimates and schedules for the baseline program. This review was to provide the basis for NASA's commitment to program cost and schedule, assuming the technical baseline established in the CETF activity. The review concluded that the Dual Keel configuration would require a total development cost of $18.2 billion (in 1989 dollars) and a slip in FEL from January 1993 to January 1994. The cost estimate included a program reserve of 35 percent to handle program contingencies.

In parallel with the cost commitment review, NASA conducted a configuration options study to develop options for the configuration which would reduce Space Station development costs. The options developed ranged from a Skylab-type Station to a phased development of the Dual Keel configuration. Under the phased approach, the development of the baseline Dual Keel configuration would be split into two phases. Phase I would provide the transverse boom without the two keels. Full-scale development of solar dynamic power was not included in Phase 1, but solar photovoltaic capacity would be augmented to provide 75kW. The co-orbiting platform and the servicing facility were deferred for future consideration. Most of the other options considered impacted user capabilities to such a significant degree that they were eliminated. The study concluded that the phased approach was technically feasible, accommodated funding constraints on the front end of the program, and was responsive to the technical and safety concerns addressed in the CETF review. It also minimized negative impacts to Station users. The Phase I Space Station was designated the Revised Baseline Configuration, with a development cost of $15.3 billion (in FY 1989 dollars) and FEL in July 1994. (Subsequent communications with the Congress resulted in a revision of FEL to first quarter CY 1994.)

National Research Council Review

In the spring of 1987, the Office of Management and Budget, the Office of Science and Technology Policy, the National Security Council, and NASA requested that the National Academy of Sciences' National Research Council (NRC) conduct an independent examination of Space Station design concepts, costs and support of user requirements. The extensive NRC review was completed in September 1987. The NRC endorsed the Revised Baseline Configuration, concluding that, on balance, none of the alternatives it had reviewed was as satisfactory a design concept. The NRC further recommended that the Space Station required a national commitment

funding in the form of multi-year appropriations to provide program stability. The NRC also concluded that the nation's long-term goals in space should be clarified before committing to any particular evolutionary Phase II design.

Transportation Study

The Space Station Program Office, in conjunction with the Office of Space Flight, conducted a joint Space Station transportation study throughout the summer of 1987. The study was conducted to assess ways to improve safety, to control and plan Space Station transportation, and to reduce the Space Station burden on the Shuttle fleet. The study examined several earth-to-orbit transportation systems, including current and enhanced Shuttles, expendable launch vehicles, and a Shuttle-derived heavy lift launch vehicle. The study resulted in recommendations to 1) baseline the current Shuttle with an enhanced down-weight capability; 2) provide 5 flights per year for operations/logistics; and 3) rotate four crew members at a time with on-orbit stay-times gradually increasing to 180 days. These results were reviewed by the NRC and baselined into the program in November 1987.

Space Station Operations Task Force

In September 1986, NASA created the Space Station Operations Task Force comprised of NASA and other United States Government experts in operational space systems. The task force was also advised by private sector experts and the international partners. The objective of the task force was to focus on NASA's past operational experience in both manned and unmanned space programs, to benefit from others' past experience in the operation of large government and private sector systems, and to consider carefully any new approaches that could increase operational efficiencies during the operations phase of the program. The task force made recommendations on operations management and cost control, and also provided guidance during the development of the Requests for Proposal for the Work Package contracts for the Station. The task force's recommendations were baselined into program in November 1987.

Science Operations Management Concepts Study

A study looking at the management of science operations on the Space Station was conducted in July and August 1987 by a group of NASA, other U.S. Government, private sector and academic scientists against the backdrop of the proposed Space Station operations concept developed by the Space Station Operations Task Force. The study focused on the science operations planning process which is inextricably linked with the overall Space Station operations planning process. Preliminary analysis indicated that the recommendations were consistent with the Station operations concept and its operations cost management processes.

Systems Options Study

A review of Space Station systems was begun in November 1987 and concluded in March 1988. The effort involved all four Work Package centers. The study was conducted to evaluate the design of each Station distributed system and to re-examine various aspects of the major systems so as to identify any technology or architecture trade-offs that might result in further up-front design and development cost savings. In many of the cases where significant reductions in non-recurring development costs could be made, it was shown that the reductions

would be accompanied by large increases in recurring operations costs in later years.

The systems options study concluded with a presentation to the NASA Space Station Management Council, comprised of the NASA Center Directors and attended by the Administrator and Deputy Administrator, in March 1988. After evaluating the selected systems on the criteria of cost, schedule, safety, mass, power, development risk, operations and user impacts, it was concluded that the systems embodied in the Revised Baseline Configuration were sound and should not be changed.